TESLA COIL OUTFIT FOR FORTY-INCH* SPARKS

- CONSTRUCTION and OPERATION -

WARNING - THIS IS A POWERFUL HIGH-VOLTAGE DEVICE, AND COULD BE VERY DANGEROUS IN THE HANDS OF AN UNSKILLED OR CARELESS PERSON!

Therefore, only those capable of and qualified for the intelligent use of high-voltage apparatus should attempt the construction or operation of this device. Sensible safety precautions must always be observed.

The voltages encountered in the operation of this device are capable of causing fatal shock and burns, and all personnel and combustible objects must be kept at a safe distance from the Coil while it is being operated. As the sparks can jump several feet in all directions, no person or object should be allowed to come any closer than TEN FEET to the coil while it is being operated, and no experiment should ever be attempted which requires closer proximity to the Coil for any reason whatsoever. No safety precaution should be considered too extreme for constant application.

NOTICE - No guarantee of performance or assurance of safety of any part of this device, in whole or in part, is expressed or implied, and Huntington Electronics, Inc., will not be responsible for any damages or injuries caused directly or indirectly by the construction or operation of this device, under any circumstances whatsoever.

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*Output of prototype coil under test conditions, and not guaranteed.

INTRODUCTION

The construction and operation of the Tesla Coil outfit described in these plans is a task of some magnitude, and is probably best-suited to the experienced builder and experimenter. All the work must be carefully and skillfully performed, and no short-cut should ever be considered.

In order to make certain details clearer, and thus avoid confusion, no attempt was made to draw the enclosed plans to any definite scale. It was felt that this would make the drawings easier to understand, and as all necessary dimensions are given in the text, as well as on the drawings in most cases, it is felt that no difficulties will be experienced.

It is believed that the plans and text are descriptive and complete to the point where the experienced builder should have no difficulty in constructing a successful outfit. At the time of this writing, the prototype coil is on display at the Boston Museum of Science, Boston, Mass., and has proven to be quite satisfactory. Of course, the success of each individual outfit is dependent upon the skill used in construction and the parts that are available to the builder. Inferior parts cannot help but degrade the final product.

The builder may be tempted to take certain short-cuts, which are certain to lead to disappointment. One area where this is likely to occur is the matter of the insulation to the secondary coil, which requires several coats of orange shellac before winding, and several after winding is completed. At least three coats should be applied both before and after, and even more coats are desirable for the finished coil. The better the insulation on the secondary, the greater the output of the coil, and the lesser the chances of insulation breakdown. Each coat of shellac should be absolutely dry before the next coat is applied.

The coil was designed in this style in order that the secondary could be lifted off the primary for ease in moving, and to make construction of each part easier. If it should be necessary to move the outfit at some time, every effort should be made to avoid scratching the secondary coil, or getting it dirty or wet. Wrapping the coil in plastic or paper should help to protect the winding from damage. The coil should be kept clean and dry.

The operation of any high-voltage discharge device will cause large amounts of ozone gas to be given off at the area of the spark. This will be noticed by its characteristic odor, and need cause no alarm in small amounts. Normal room ventilation should take care of the amounts likely to be encountered in the use of this device. As mentioned elsewhere, the coil should only be operated in short "bursts" in order to avoid overloading and overheating the components, as well as to reduce the chances of radio and television interference.

It is strongly suggested that the complete coil outfit be kept in a large room by itself, with a wood floor or similar dry surface with good insulating characteristics. Cellar floors should be avoided. As mentioned elsewhere, the coil will require a high ceiling for safe operation. In some cases, an attic area may be suitable, where the additional height due to the peak of the roof can be used to good advantage. A door which will lock securely should be provided to keep children from tampering with the equipment, which would certainly occur if the device was accessible to them. Further, the master switch, as mentioned elsewhere, should be kept locked in the "off" position whenever the coil is not being used. Only when stringent precautions are observed can experimenting be conducted with any degree of safety.

The experimenter is advised to read all available literature on the subject of high-voltage high-frequency electricity, in order that he will better understand the principles and theory of the fascinating device with which he will be working. If possible, a copy of Nikola Tesla's book, "Experiments With Currents of High Frequency and High Potential", should be obtained, as this is one of the best works on this subject.

Secondary Coil and Winding Device

The secondary coil, shown in Figure 1, consists of a heavy cardboard or Duro tube, 52" long and 20" diameter, fitted with wooden heads on each end. A coil of 600 turns of #22 Heavy Formvar magnet wire is wound on the tube at a rate of twelve turns per inch for 50 inches, leaving an inch of space at each end of the tube. The wire can usually be obtained from a motor-rewinding shop, or from wire distributors such as Magnet Wire Inc., 25 Walker Street, New York 13, N. Y. The tube can usually be found at the larger building supply houses. One type is called a Sonotube, and is made by the Sonoco Products Co. of Mystic, Conn., and sold through building supply outlets for cement forms. The tube must be absolutely dry and free from any conductive coatings.

The heads or ends are cut from 3/4" thick Novoply or plywood, and should be a tight fit in the ends of the tube. A 1" hole is drilled in the exact center of each head. The heads are pegged in their final position in the ends of the tube with 1/8" maple dowels, as no nails or screws can be used in the secondary. After the heads are installed, both heads and tube are given several coats of orange shellac, allowing a full 24 hours of drying-time between each coat, after the last of which it is ready to be wound with the wire.

Approximately 3200 feet of #22 Heavy Formvar wire will be needed. This will probably come on a small metal spool, which can be supported on a suitable free-turning spindle while winding the coil.

The winding can be done on a large lathe, or if one is not available, a suitable device can be rigged up for the purpose, as shown in Figure 5. A small motor-gear-reducer device of about 20 r.p.m. is belted to a shaft of 1" diameter, supported in suitable bearings, on which the tube is placed and locked in position with a clamp at one of the heads. The 1" holes in the heads should locate the shaft in the center of the tube, and thus make it run perfectly true. It should turn slowly, away from the operator. Near the first shaft and parallel to it another shaft is mounted in bearings, and belted to the first shaft. This shaft is a threaded rod, 5/8-11, with the ends turned down to take pulleys and fit the bearings. This rod can be found at larger hardware stores in most cases, and comes six feet in length. Pulleys are chosen of suitable size that will permit the threaded shaft to turn with the tube shaft at such a rate that a point following the threads will move to the right one inch for each twelve turns of the tube. In the original case, a 3 1/4" pulley on the tube shaft and a 3 1/2" pulley on the threaded shaft was found to be quite correct. A wire-guide can be made from two nuts that fit that shaft, and a piece of Masonite which is screwed across the flats of the nuts, in position 2" apart on the shaft. The Masonite piece is kept from turning with the shaft, and the wire is fed through a small hole drilled in the top of the Masonite piece. The supply spool for the wire is kept some distance behind the operator, and winding tension is applied with a leather glove on the hand. The winding is begun with the hole in the guide at a point perpendicular to the starting point on the tube. This point should be 1" from the left end of the tube, and a small hole is drilled in the tube. A few feet of the wire are pushed inside the tube for later access, and the hole made snug with a tapered toothpick driven in alongside the wire. The winding is then begun, with the tube turning slowly away from the operator, and light tension being applied to the wire as it is being wound. After 50 inches (600 turns) are wound, another small hole is drilled in the tube and a few feet of wire pushed inside, and plugged as before. The finished coil is then given several coats of shellac, well-dried between each coat. A copper contact ring, 3" in diameter, with a 1" center hole, is fastened in the center of each head with copper tacks, and the wire inside each end of the tube is fished out and soldered to the contact ring on each end.

A wooden imitation insulator is made up of discs of wood, with a brass rod running through the center, topped off by a 3" brass ball fastened to the rod. A copper contact ring is soldered to the bottom of the rod, in position flat against the bottom of the insulator, which will make contact with the contact ring on the top of the secondary coil, upon which it will be placed.

Tesla Coil Primary and Base

The primary coil, as shown in Figure 2, consists of eight turns of 2-inch wide copper strip, of the type that is commonly used for roof flashing, wound in a spiral with a 24" inside diameter, and with a double thickness of 1/4" corrugated cardboard between each turn to act as a spacer and insulator. The coil is tapped at each turn, and leads brought out to a terminal board on the front of the base, which has nine binding-posts on it.

Construction is best begun with the base. This is a 36" square of 3/4" plywood, well-dried and coated with several coats of shellac. Six-inch glass insulators are mounted on the bottom in each corner, to act as legs. A one-inch tapered maple dowel is mounted in a hole in the exact center of the top of the base; this will serve as a locating-pin for the secondary coil. A copper ring, made of the flashing copper, and measuring about 3" in diameter with a 1" hole in its center, is slipped over the maple pin, and secured to the base with copper tacks. This will serve as a contact ring, and will make connection with a similar ring mounted on the bottom of the secondary coil.

A 24" diameter circle is then drawn on the base, with the maple pin as its center. Twelve 3/8" holes are drilled, equally- spaced, along this circle, and 3" long maple dowels are glued in the holes. These dowels will act as a coil form for the primary, and also locate it concentric with the center of the base.

A slot 2" wide is cut in the base, starting at a point about 11" out from the center pin, and continuing outward for about 6". This is to permit taps to be soldered to the primary turns after the primary is mounted on the base.

A terminal board of phenolic or Masonite, about 3" wide, 20" long, and 1/4" thick is screwed to the front edge of the base, in the center. Nine binding posts are mounted on the board, equally-spaced. Terminal G or GRD at the left is the ground terminal, and is to be connected to the copper contact ring in the center of the base, and also to the starting or inside turn of the primary coil. The other terminals, numbered 1 through 8 are to be connected to the respective taps on the primary turns.

The coil itself is wound next. The starting end of the copper strip is secured to the dowel nearest the access slot in the base. The coil is then wound, using the dowels on the 24" circle as a form. Two thicknesses of 1/4" corrugated cardboard, 1 3/4" wide, are wound between the turns of copper at the same time, to act as insulator and spacer. After winding, the primary is bound with plastic tape at several points to hold it together.

A heavily-insulated wire is then run from the starting point of the primary coil to the copper contact ring, and also to terminal G on the terminal board. All connections must be carefully soldered. Wires are also run from each of the remaining eight terminals to respective turns of the primary, keeping the wires separated and away from the rest of the primary. Soldering the taps to the copper strip is no problem, as the cardboard separating strips are 1/4" narrower than the copper strips. Terminal one is connected to turn one, and so on for all eight turns.

If desired, a decorative cover can be made for the primary. This would be a bottomless box, 4" high and 36" square to match the base, and a top made of 1/4" Masonite with a 24" diameter hole cut in the center to clear the secondary coil by a safe margin. This should be well-dried and shellacked, also. This adds to the appearance and keeps dust from collecting between the turns of the primary.

As in the secondary coil construction, no steel or iron fastenings should be used anywhere in the primary. Wooden pegs, glue, and copper nails can be used sparingly, with no harmful effects.

Standard Spark Gap

The standard spark gap, as shown in Figure 3, is a comparatively simple device, suitable for intermittent use at low power. It is not as efficient as the rotary gap, but is much easier to build.

The base is made of 3/4" thick phenolic, 6" wide and 12" long. If the phenolic is not available, well-dried and shellacked maple could be substituted. The phenolic is preferable due its superior insulating properties.

Along the center-line of the base, and 6" apart, are mounted two brass uprights, measuring 1" square and 4" in height. These are secured to the base with 1/4-20 screws tapped into the center of the bottom of each upright, and passing through holes counterbored into the underside of the base. Each upright has a 1/2" hole cross-drilled at a point 3/4" from the top, which is to take the electrode rods in a smooth sliding fit. A 10-32 set-screw is tapped into the top of each upright, extending into the 1/2" drilled area in order to bear on the sliding electrodes and hold them in position.

The electrodes are made of 1/2" stainless steel rod, and are 6" long each. If stainless steel is not available, brass rod could be substituted. The electrodes are accurately faced off on the ends, in order to present a true sparking surface where they come nearly together over the center of the base. The uprights are so positioned when being mounted to the base that the electrodes will oppose each other in a straight line, center-to-center, when pushed together over the center of the base. Suitable rubber grips can be made of rubber tubing, and forced over the outside ends of the electrodes to serve as convenient handles. It should be fully understood that these grips do not constitute a safe insulator for the high voltage present at this point when in operation, and no attempt should ever be made to adjust the gap or change connections with the current turned on.

A 10-32 terminal screw is tapped into the side of each upright at a point near the base, to facilitate connection with the rest of the apparatus.

After the uprights are mounted in their final position on the base, the counterbored holes on the underside of the base must be filled with some good insulating compound, to insulate the screw heads. Further, it is a good idea to place the entire gap unit on a sheet of heavy glass for further insulation when in operation.

Rubber feet are installed on the four corners of the underside of the base to provide a non-slip footing for the device.

In use, the gap length will probably range from 3/16" to 3/8", and should be adjusted in small amounts (with the current off) until the most efficient point is found, at which time the Tesla Coil will deliver its maximum output.

Once the correct gap distance is found, the set-screws should be securely tightened to prevent the gap length from changing.

In use, the outfit should only be operated for very short periods, of a second or so, as the gap will heat up and the electrodes burn away in time.

The gap unit can be fitted with a protective peg-board cover, the holes of which will serve to ventilate the unit; this cover will help prevent accidental contact with the metal parts of the device.

The finished gap device can be mounted a few inches away from the transformer, across the secondary of which it is to be connected, as shown in the wiring diagram, Figure 7. Keep the gap unit at least six feet away from the base of the Tesla Coil. The same rule applies to the condenser as well.

Rotary Spark Gap

The rotary gap device, as shown in Figure 4, consists of a motor-driven insulating disc, on which are mounted fourteen brass studs or electrodes, all connected electrically, on a nine-inch diameter circle. The disc is rotated in close proximity to, but not touching, two stationary electrodes, which are mounted on threaded spindles on an insulating upright parallel to the disc. The high-voltage current is applied to the two stationary electrodes, and the spark takes place between the two stationary electrode faces and the faces of diametrically opposite moving electrodes. The air currents generated by the moving parts tend to cool the electrodes, and the movement of the electrodes away from each other tends to "wipe out" any arc that might form in the gap. As this arc would act as a short to the transformer, it would have a deleterious effect on the output. Therefore, the rotary gap is superior to the standard gap, both mechanically and electrically.

The base, made of phenolic or maple, is 3/4" thick, 12" wide, and 24" long. Rubber feet are fitted to the bottom four corners.

The motor is a small 1500-r.p.m. type, with a base that will locate the shaft about 6" off the base. The Dayton #3M-051 motor with #IC-897 metal base is ideal for this application. The motor-base unit is mounted near the center of the gap base, and fastened securely.

The hub is made of steel, and is 2" in diameter and 3/4" thick, with a center hole drilled to take the motor shaft. A set-screw is fitted to lock the hub to the shaft. The hub's outside face should be accurately faced-off in a lathe in order that it will run perfectly true with the shaft. Four 10-32 holes are tapped into the face of the hub, on a $1\frac{1}{2}$" diameter circle, equally spaced. The hub is mounted in the exact center of the disc by screws.

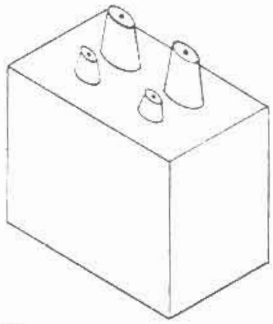
The disc is of phenolic, 1/4" thick and 10" in diameter. A 9" circle is marked out concentric with the center, and fourteen points marked off, equally-spaced along the 9" circle. Clearance holes are drilled at these points for 8-32 screws that will be used to mount the studs or electrodes.

The fourteen studs are made of brass rod, or stainless steel if available, and measure 1/2" diameter and 1/2" long each. They are tapped with 8-32 holes for the mounting screws. The studs should be faced-off to present a true outside sparking surface. The studs are mounted to the disc with 8-32 machine screws, and a copper wire is run under the head of each screw on the back side of the disc to connect the studs electrically together. This wire is run on the 9" circle, and kept away from the hub at all points. The finished disc assembly should be balanced on knife-edges, using a small piece of suitable shafting. This should assure vibration-free running. The disc should run perfectly true in its final position on the motor shaft.

The stationary electrodes are made of brass or stainless steel rod, and measure 3/4" diameter and 3/4" long, and are faced-off as were the others. They are mounted on threaded spindles passing through the 3/4" thick phenolic upright, 9" apart center-to-center, at the same height as the motor shaft, and laterally located with the motor shaft at the mid-point of the 9" spacing. This is in order that the stationary electrodes will accurately oppose the rotating electrodes as each "pair" passes by.

Lock-nuts are fitted to the spindles, and the gap is set to the point where the electrodes just miss striking. Lugs are fitted under the lock-nuts, and wires are run from the lugs to suitable binding-posts located on the phenolic upright, near the base, which will provide the high-voltage connection point. Connect in same manner as regular gap unit, but make certain that a ground wire is run to the motor's metal base. In use, the gap motor is always started and allowed to pick up speed before the high-voltage current is turned on. A ventilated cover of pegboard is a desirable final feature for the rotary gap, and should be provided. All the wood parts should be heavily shellacked.

High-Voltage Transformer



Illustrated at the right is a common style of high-voltage plate-type transformer which could be used to power this Tesla-coil outfit. The case is of metal, and usually oil-filled and hermetically-sealed. On the top of the case are found the porcelain terminals, the smaller of which are the primary terminals, and the larger ones are the secondary terminals, in most cases. Transformers of the size needed here are quite large and heavy, and could weigh from 50 to 150 lbs.

For powering the outfit described in these plans, a primary voltage of 110-120 volts will be the most convenient, although a 220-volt unit could be used if only this rating were available to the builder. The secondary can range from 6000 to 9000 volts, at a current rating of up to 275 milliamperes. Higher voltages are not to be desired, as they would increase the chances of shorting, shock, and insulation failure. Higher amperages are equally undesirable, as they would increase the already formidable shock hazard, and cause unnecessary heating of the spark gap unit and condenser, increasing the chances of failure of these units.

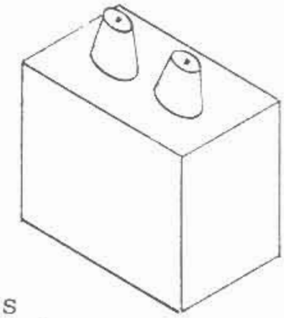
The transformer used to power the prototype coil was rated at 7500 volts at 275 milliamperes, for the secondary, and 110-volts for the primary. This was sufficient power to drive the coil to produce a forty-inch spark to a grounded terminal electrode, and this should certainly be spectacular enough for any sensible purpose the builder may have in mind.

Transformers of this size and rating are dangerous to work with, and great caution should be observed whenever working in proximity to them. No attempt should ever be made to change any connections or make any adjustments with the power on. The master switch should be of the locking type, and kept locked at all times when the coil is not in operation. This will prevent anyone (including the operator) from turning on the power by mistake, and will also prevent children and unauthorized adults from tampering with the outfit in the owner's absence.

Transformers of this type can usually be obtained from the same sources listed in the condenser section, and can range in price from $35.00 to $150.00 each, depending on conditions at the time. If this type unit is not immediately available, a smaller unit, of the neon-sign type could be used, but with much less output, of course. Neon transformers can usually be obtained from sign-shops and junk-yards at a reasonable figure. If the neon type is used, it might be necessary to reduce the condenser capacity to allow for the reduced power in this event. In any case, every effort should be made to secure the proper transformer, which, in return, can be expected to provide the desired results, with small chance of failure in normal use.

The transformer, as well as the condenser and gap units, must be kept at least six feet from the base of the Tesla Coil at all times. The wires used to connect the transformer <u>secondary</u> with the gap unit and condenser must be of the high-voltage type, capable of carrying the secondary voltage and amperage without danger of shorting or overload. A suitable type wire for most purposes is the type #15-GTO, which is sold for use by the neon-sign trade. This same wire should be satisfactory for connecting the above units to the primary of the Tesla Coil. On the <u>primary</u> end, #12 cable should be satisfactory if the transformer draws less than 20 amperes. If it draws more, #10 or heavier should be employed. The locking switch should have its case securely grounded, and carry fuses of a size that will just barely carry the load, thus assuring that the fuses will blow at the slightest overload. The switch should be located at least <u>ten feet</u> from the Tesla Coil itself. The line supplying the transformer should run directly from the incoming service, and be fully capable of carrying the load. Local electrical codes should be observed in all cases.

High- Voltage Condenser



Illustrated at the right is an example of a suitable high-voltage condenser (or capacitor) which can be used in this Tesla outfit. These condensers are oil-filled in most cases, and are made in many sizes and ratings; a good choice would be one with a capacitance of about .1 mfd., and a voltage rating of about 20,000 volts, or more. A comfortable margin of voltage-handling capacity is always desirable in components of this type.

Although one single unit of the proper type and rating is to be preferred, if such is not available, certain units can be combined to achieve the desired rating. For example, two units of .05 mfd. can be wired in parallel to give the desired .1 mfd. resultant. On the other hand, two units of .2 mfd. could be wired in series to give .1 mfd. In any event, only units capable of handling the required voltage should be considered, and a large margin is in all cases to be preferred.

When the original coil was built, no suitable .1 mfd. condenser was available, and it was necessary to use twelve smaller units in a series-parallel circuit to provide the necessary .1 mfd. This worked satisfactorily, but was a very clumsy arrangement, and a single-unit condenser of the proper value was acquired as soon as possible to replace the twelve separate units.

For condensers in parallel, their capacitances are simply added. For condensers in series, the following formula is used:-

$$\frac{1}{Ct} = \frac{1}{C1} + \frac{1}{C2} + \frac{1}{C3}$$

, etc., where Ct is total or resultant capacitance, and C1, C2, and C3 are condensers connected in series. All voltage ratings should be 20,000 volts or more.

This type single-unit condenser is usually quite large, weighing about thirty to sixty pounds or so. They are usually mounted in a metal case, oil-filled, and hermetically-sealed. The high-voltage terminals are usually on the top of the case, and porcelain stand-off insulators are used.

Condensers of this type can usually be obtained from the larger radio and electronics supply houses, such as Barry Electronics, 512 Broadway, New York City, and R. W. Electronics, 2244 South Michigan Avenue, Chicago, Illinois. They will not be in stock at all times, but if several suppliers are contacted, a suitable unit can usually be found. Prices will vary widely in different areas at different times, and can range from $15.00 to $50.00 or more per unit. It is a good idea to obtain several issues of the radio-electronics magazines, as they often contain ads for condensers and transformers of the type needed here, or at least will list the names of several suppliers which can be contacted.

The condenser is connected into the circuit as shown in the wiring diagram, using suitable high-voltage cable with the best-possible insulation. It can be mounted fairly close to the transformer and gap unit, but must be kept at least six feet away from the Tesla Coil itself. This is to prevent arcing from the coil to the other units, which must be prevented at all costs.

For convenience, the transformer, gap unit (either type), and condenser can all be mounted on a single wood base, fitted with casters for easy handling. Each of the three units should be kept at least six inches from each other, and the wires routed carefully from unit-to-unit in such a way as to prevent any possibility of shorting between units or shorting to ground or to the 110-volt transformer feed line, or to the gap motor feed line if the rotary type is used. A protective cover of peg-board can be made for the base, and thus prevent anything or anyone coming in contact with either of the three units. As condensers under certain conditions can hold a residual charge, it is a good idea to carefully short out the condenser terminals with a piece of high-voltage wire before working on the circuit.

Final Assembly and Operation

The assembled Tesla Coil is shown in Figure 6. The completed secondary coil is placed in the center of the primary coil, on the base as shown. The tapered locating pin on the base should center it exactly. Also, the copper contact rings (one of which is on the base and the other of which is on the bottom of the secondary) should come together in this assembled position.

The brass discharge ball, with its imitation insulator, is placed in its final position, in the center of the top of the secondary. Here again, the copper contact rings (one of which is on the top of the secondary and the other of which is mounted on the bottom of the "insulator") should come together, and make contact.

The overhead discharge terminal or target is mounted in position, at a point about 36" above the top of the brass ball. This can be any heavy piece of brass or copper, and must be very securely grounded, using a heavy wire, which must not be allowed to come within five feet of the side of the secondary at any point, otherwise arcing could occur with possible damage to the coil. Another heavy ground wire is run to terminal GRD on the terminal board, shown as G in Figure 6. This will ground the inside turn of the primary coil, and, through the copper contact ring on the base, the bottom turn of the secondary coil. A cable that is very good for these ground conductors is marketed for use by the lightning-rod installers, and should be relatively easy to obtain. It is of heavy copper construction, and should be able to handle any load likely to be encountered here. As the completed coil will measure nearly six feet in height, and as the spark can jump in the neighborhood of 40 inches, it should be obvious that a very high ceiling will be required in the room where the coil is to be used. A room with a ceiling height of 11 feet or so is ideal; the coil should be placed quite near the center of the room, with the grounded terminal hanging from a point on the ceiling above the coil, or slightly to one side of the coil's center. The sparks tend to jump upward, rather than outward or downward, and seem to be most impressive when they jump upward at a slight angle to the target terminal overhead. The "earth" ground point, where all the ground leads will be connected, must be of proven value. If in doubt, a new driven-ground should be made, according to local electrical codes as they would apply to service-entrance grounding requirements. In some cases, a cold-water entrance pipe from under-ground can be used.

The transformer, condenser, and spark-gap device (whichever type is used) can all be mounted on a common base, provided with casters. A space of six inches or more should be maintained between units, to prevent any possibility of shorting. They should be wired according to the wiring diagram, Figure 7. Wire with high-voltage insulation should be used, and leads kept as short as possible and not touching each other or anything metallic or conductive. A suitable wire is sold for the neon-sign trade, and is called #GTO-15 by one manufacturer. This should be satisfactory for most cases. The entire transformer-condenser-spark gap combination must be kept at least six feet from the base of the Tesla Coil. Heavily-insulated cable is used to connect the combined units with the terminal board on the base of the coil. As shown in the diagram, the gap shunts the output of the transformer, and the condenser is wired in series with the primary; one lead from the gap is the ground side, and runs to terminal G or GRD on the terminal board, which is already grounded to earth as above. One lead from the condenser is connected to the gap on top end, and the other lead runs to one of the eight primary tap terminals; #3 is shown, and is a good starting point. If the rotary-gap unit is used, the high-voltage connections are the same as for the standard gap, and the motor line cord is simply run to a convenient outlet, making certain that the line cord does not come near any high-voltage terminals or wires. Also, make absolutely certain that the metal motor base is securely grounded with a separate heavy wire.

The master switch, which is enclosed in steel box, is of the double-pole type, containing two fuses and provided with a foolproof locking handle. The handle should be kept locked at all times in the operator's absence, in order to prevent anyone from attempting to fire the coil without qualified supervision. The metal case of the switch is securely grounded, and the supply line feeding the switch input should be a separate line direct from the incoming electrical service, and well-able to carry the maximum load required by the outfit. Local electrical codes should be observed in all cases. Fuses are chosen of a size that will just barely carry the load. This will insure the fact that they will blow at the slightest overload, and thus protect the equipment and line. The switch should be mounted fairly high on the wall, and must be at least TEN FEET from the coil itself. This will enable the operator to control the coil with no danger of flash-over from the coil. A barrier should be erected to keep all observers at least ten feet from the coil at all times. Accidents can only be prevented when foolproof precautions are observed, with no exceptions.

From the output of the switch, heavy cable is run to the transformer. If the transformer draws less than 20 amperes, #12 cable should be sufficient. If it draws more, heavier cables must be used; again, local codes should be observed.

Having connected up everything as outlined above and shown on the wiring diagram, and having made certain that the proper separation of units has been maintained, the experimenter should be ready for the first trial firing of the coil. The gap motor is always started before the high-voltage is applied, if the rotary-type gap is used, and the condenser lead connected to primary tap #3 for the first trial.(If the standard gap is used, it should be set for about 1/4" gap length; in the case of the rotary unit, it would be set at the point where the stationary electrodes just miss striking the moving electrodes). The master switch is then closed for one brief instant only, at which time the discharge ball on the secondary should give off a bright blue discharge and a spark should jump to the grounded target terminal. If not, other taps on the primary should be tried. <u>After shutting off the power,</u> connect the condenser lead to terminal #4 instead of #3, and try again. If this improves the output, go on to try #5, etc., until the point of greatest output is found. If the output diminishes as each step upwards is taken, try going back to tap #2. Some point will be found where the output will be at its maximum, at which time the circuit is said to be in resonance. Sometimes a very minor adjustment of the gap length will help to achieve maximum output. Make certain that all power is shut off before attempting to change any connections or make any adjustments. The coil should be fired only in short "bursts" of a second or so, as all the component parts operate under a severe strain, and prolonged operation would increse the chances of an equipment breakdown. Also, all Tesla coils cause some local radio interference, and the device should be operated at times when neighbors are least likely to be listening to their favorite programs. If sensible considerations are observed, no complaints are likely to be encountered.

It must be kept in mind that the Tesla current will jump a considerable distance, in fact several feet, to strike any grounded object. Therefore, a cleared area should surround the coil on all sides, and all combustible substances kept at a safe distance from the sparks. The room in which the coil is to be used should have a dry wood floor, or some other material with good insulating properties. This will prevent the connecting cables from shorting out where they lay on the floor. It is best in any event to keep all cables off the floor by the use of suitable stand-off insulators.

An elaborate control panel, while not necessary, can be provided if desired. Indicator lights, meters, relays for remote control, etc. could be included.

It might be well to state that the term "Tesla Coil" is loosely used here, as the true Tesla coil had a horizontal secondary coil where this type uses the vertical secondary, and for several other reasons. As the type described here is easier to build and use, this style has been chosen for these plans.

Figure 1. Tesla Secondary Coil:-

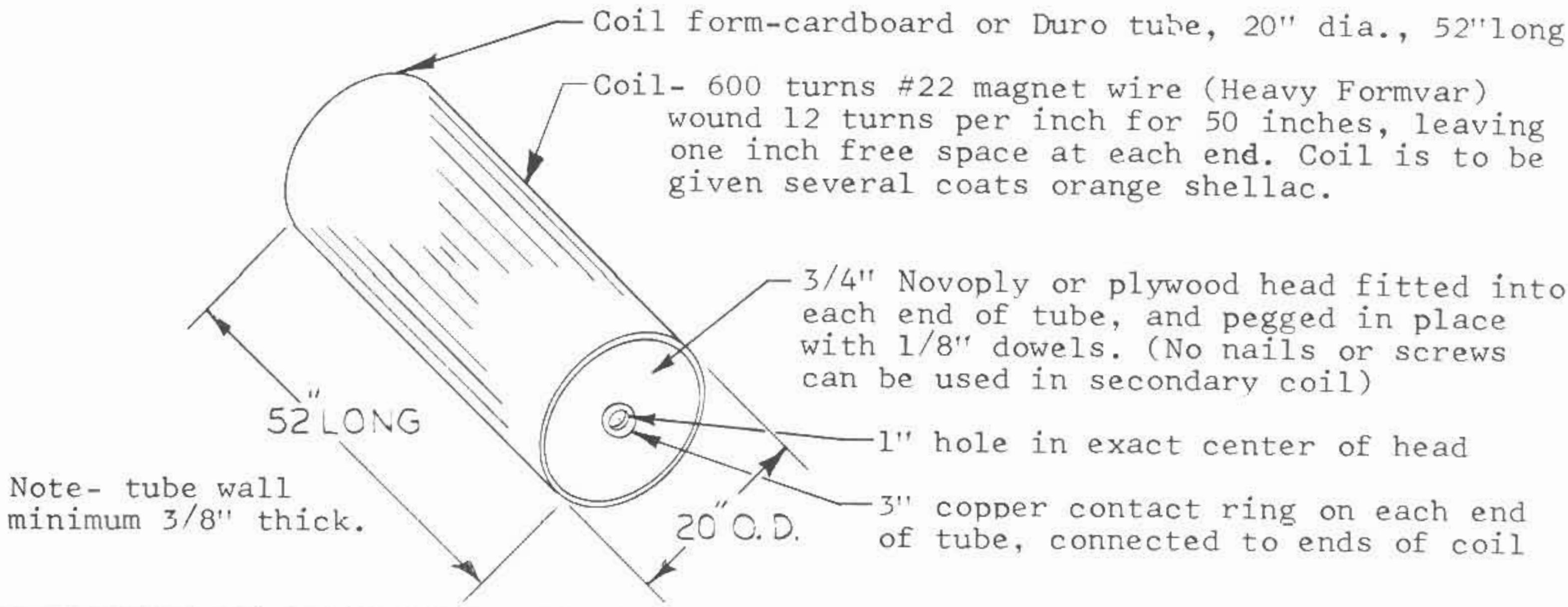


Figure 2. Tesla Primary Coil and Base:-

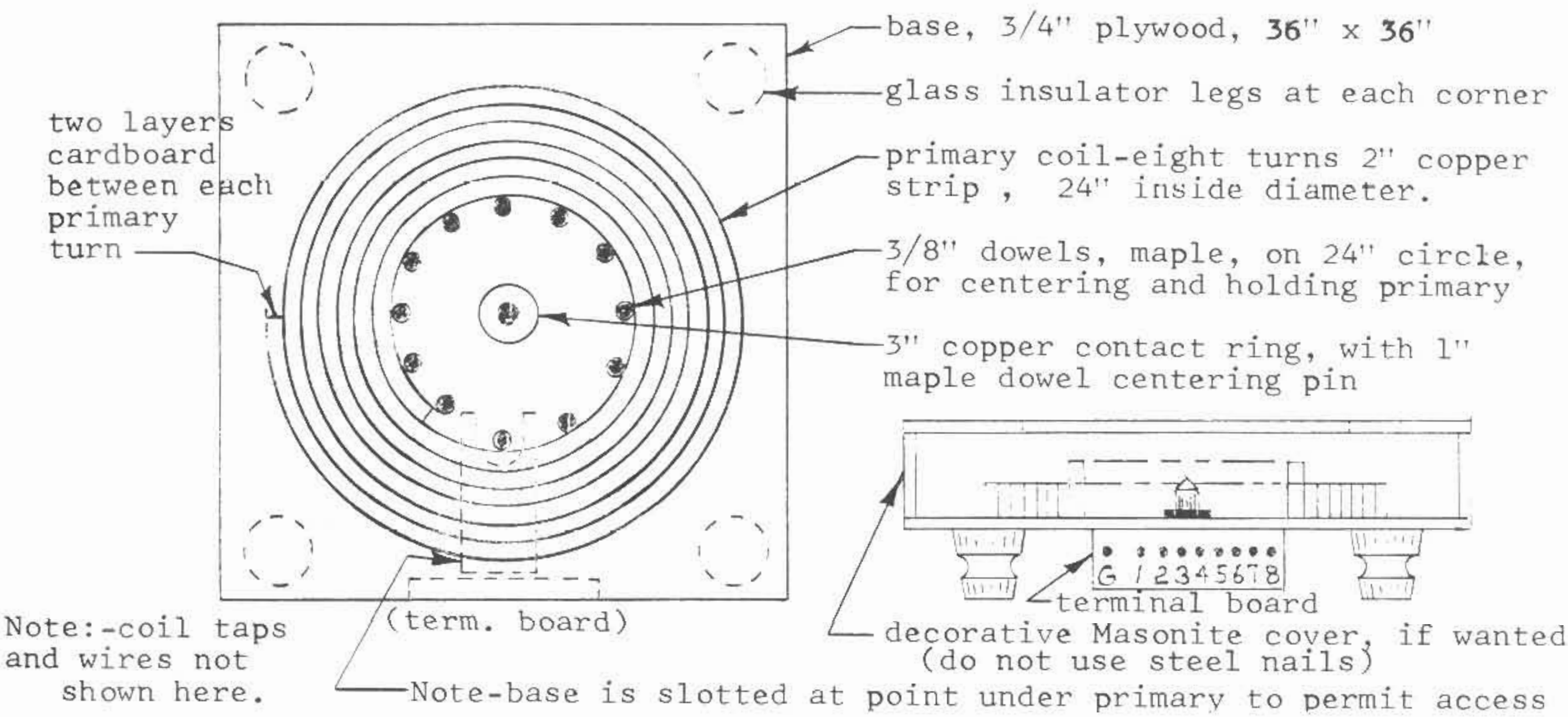


Figure 3. Standard Spark Gap:-

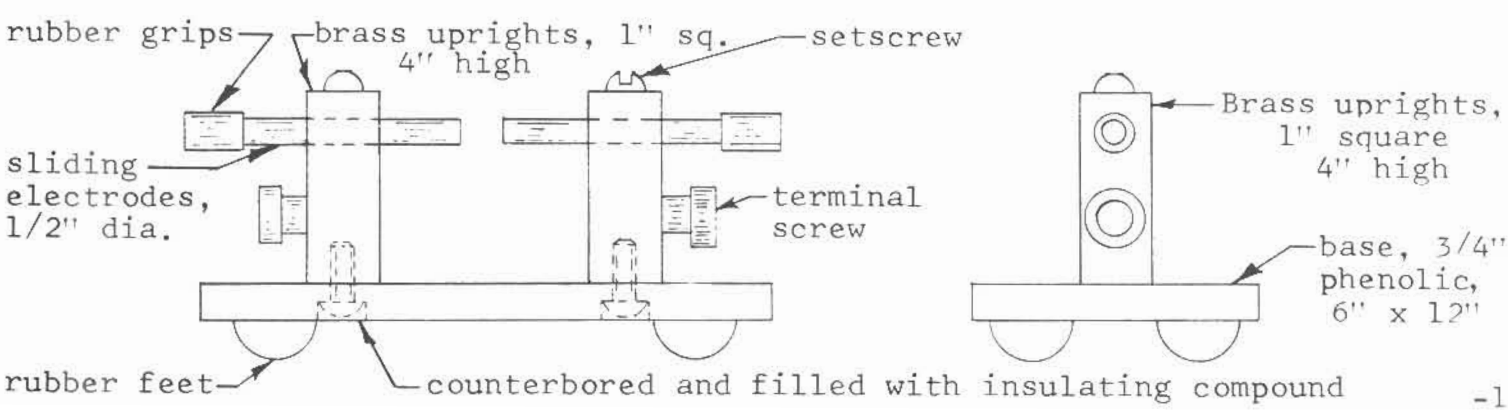


Figure 4. Rotary Spark Gap:-

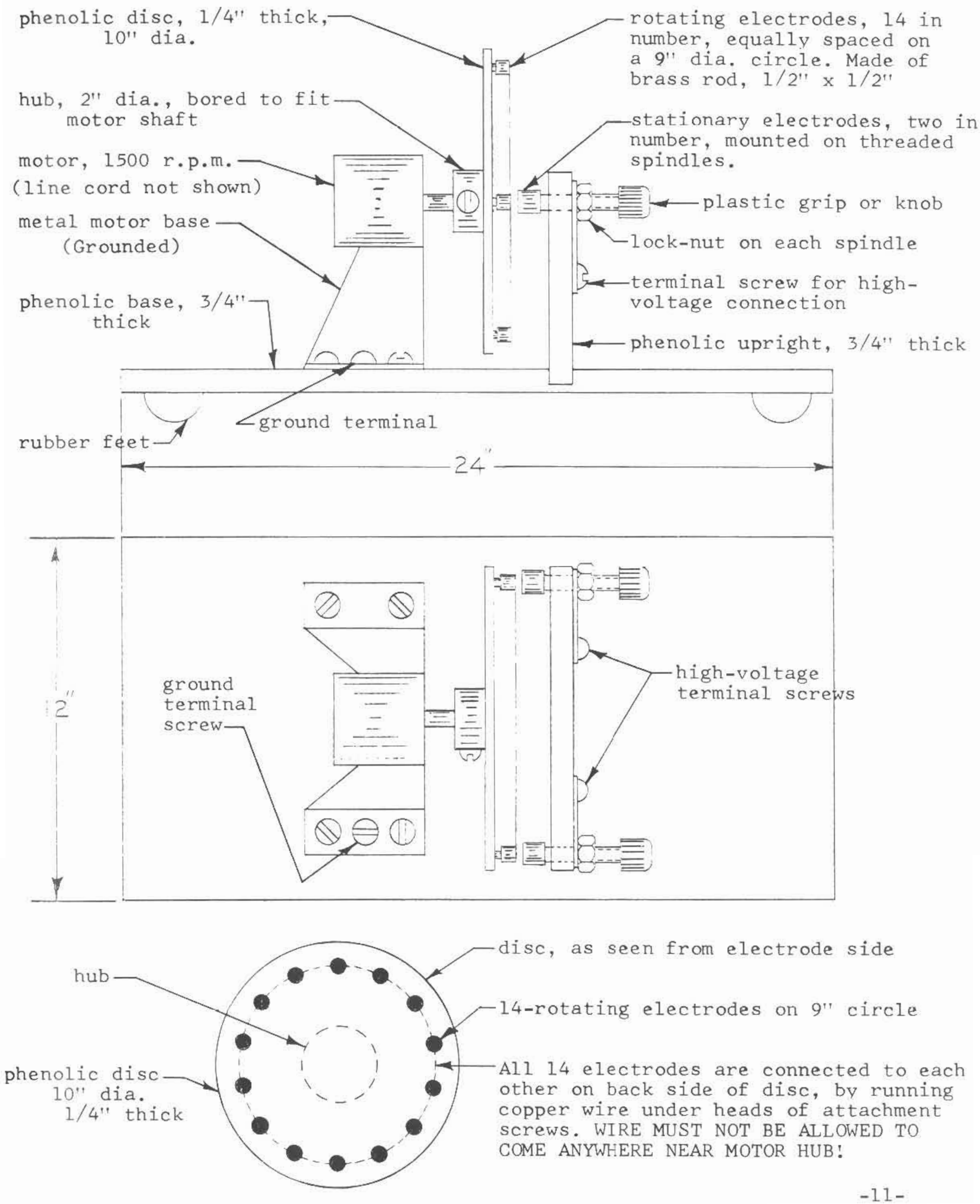
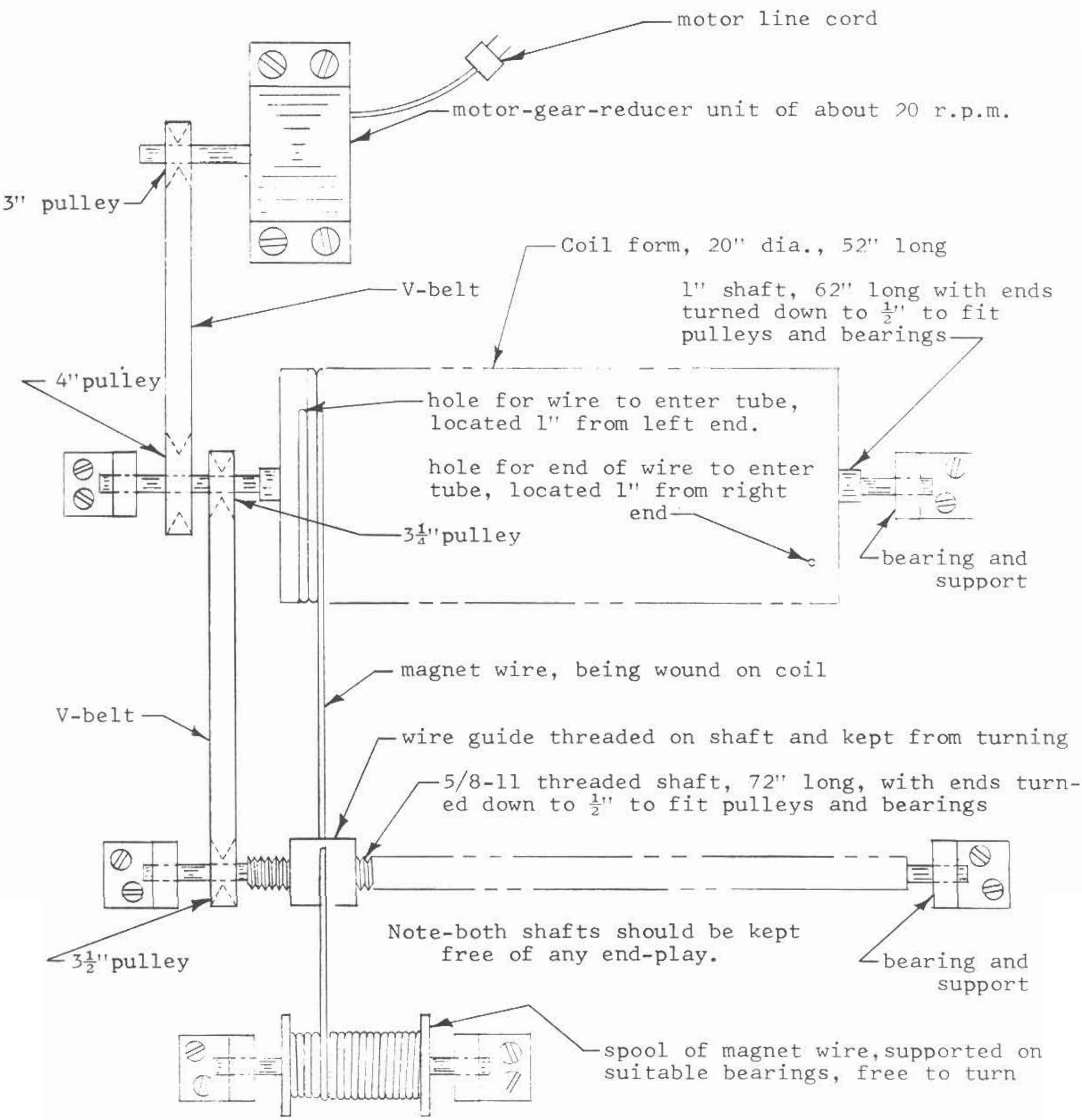
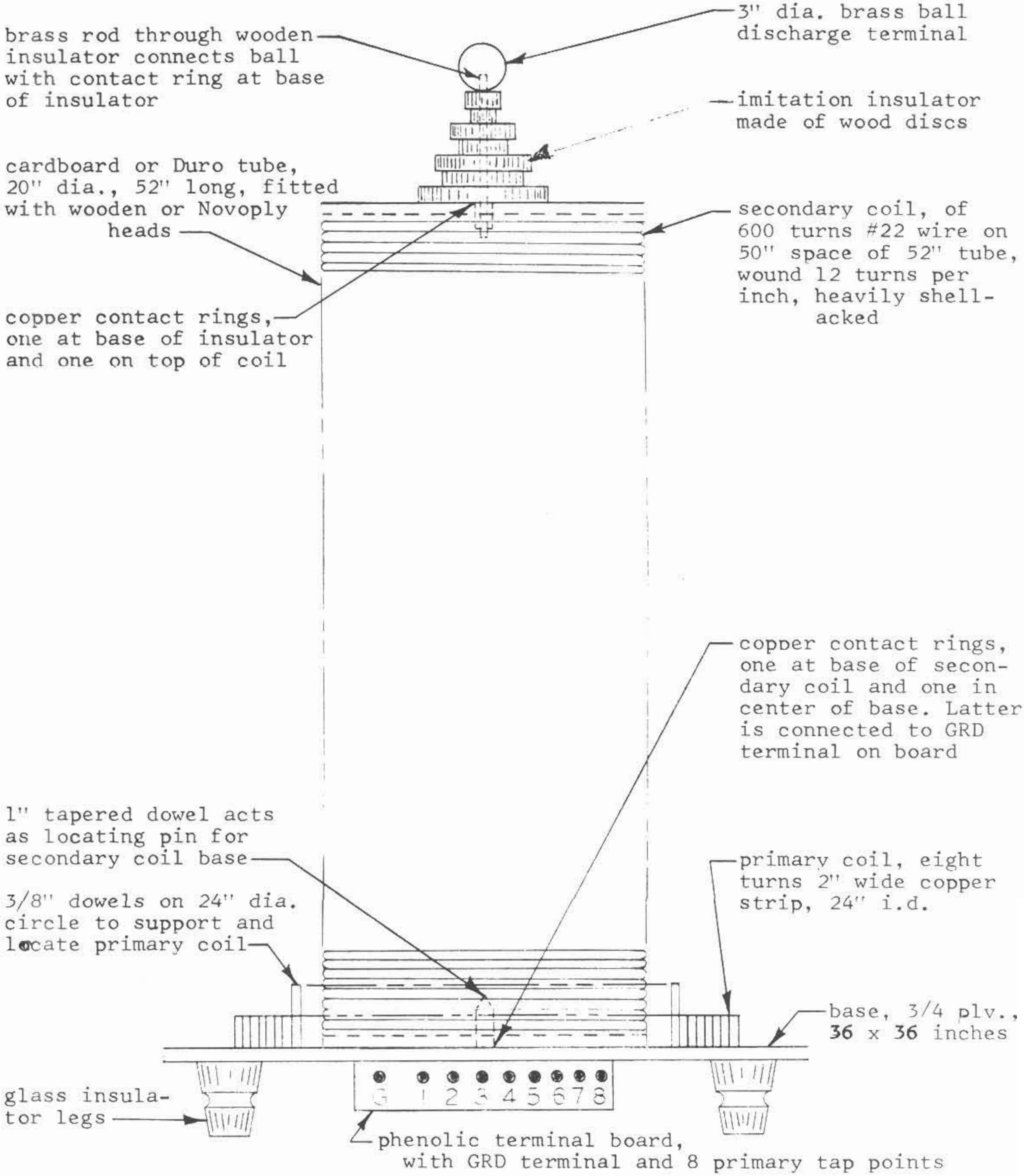


Figure 5. Winding Device:÷



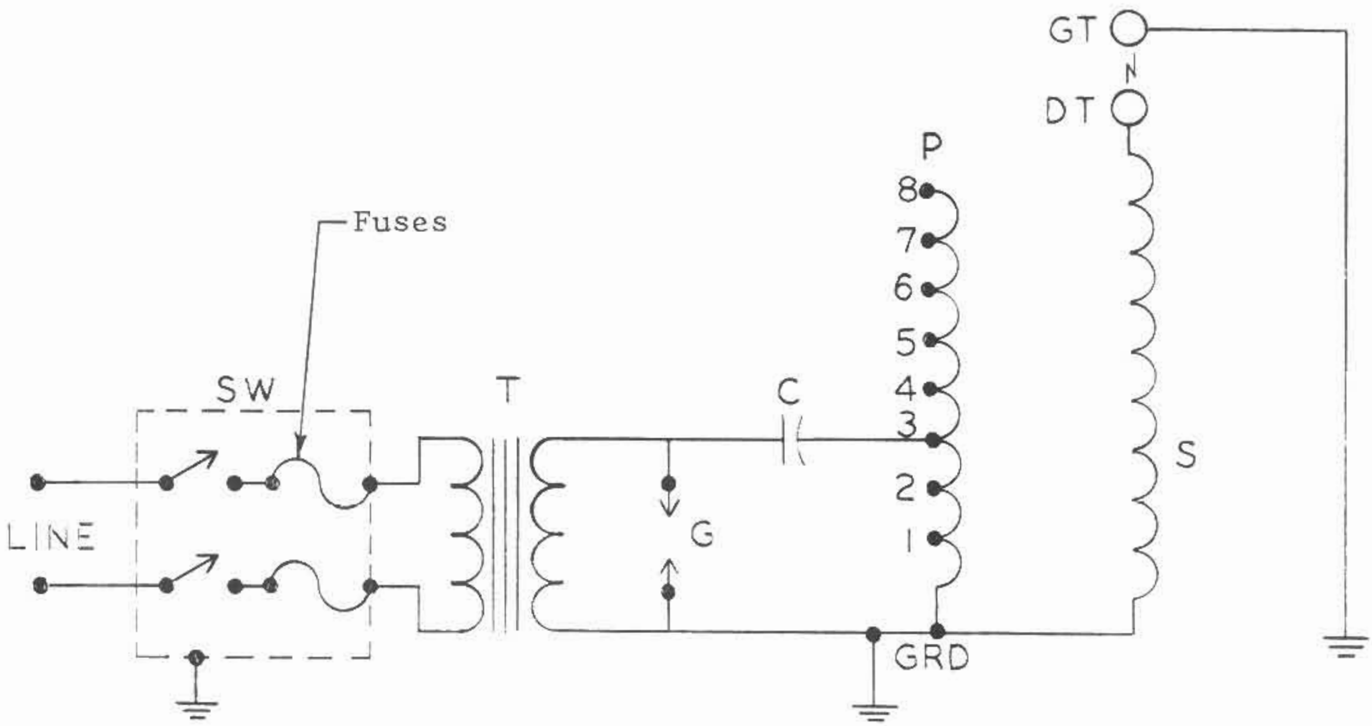
Note-moderate pressure is apllied to wire as it comes off supply spool by means of leather glove worn on hand. Belts must not be allowed to slip.

Figure 6. Assembled Tesla Coil



Note- Keep coil and base in dry area, and free of dust and dirt at all times.

Figure 7. Wiring Diagram:-



Line refers to an adequate power source, usually 110-120 volts, 60 cycles A.C., capable of supplying needed amperage, without overloading.

SW is a heavy-duty fused safety switch, enclosed in a steel box and provided with a locking handle. The box or case must be securely grounded, and fuses should be used of a value that will blow at the slightest overload.

T is high-voltage plate-type transformer; voltage at the secondary should not exceed 9000, current not to exceed 275 milliamperes. Primary should be 110-120 volts at 60 cycles.

G is the high-voltage spark gap, either of the standard or rotary variety. In the latter case, a line cord to supply the motor will be needed, which is not shown above. The high-voltage connections will be the same for either type device, and the line cord of the rotary unit can be plugged into any convenient outlet. It is imperative that the motor frame of the rotary gap be securely grounded. See text for details.

C is the high-voltage condenser or capacitor, rated at about .1 mfd., 20,000 volts. See text for full description.

P is the Tesla primary coil, comprised of eight turns of 2" copper strip, tapped at each turn as shown. Inside turn is grounded, along with secondary ground

S is the Tesla secondary coil, comprised of 600 turns of #22 heavy Formvar magnet wire wound on a form 20" dia., 52" long. Bottom of coil is connected to inside turn of primary, as above, and grounded at terminal GRD.

GRD is the ground terminal at the terminal board for connecting ground wire to both primary and secondary coils, as above..Marked G on terminal board.

DT is the high-voltage high-frequency discharge terminal at top of secondary.

GT is a suitable grounded terminal located above and about 36" away from DT, and functions as a safe target for the high-voltage discharges given off at DT.

Note-all ground wires should be of heavy cable, and kept away from high-voltage leads at all points. All high-voltage leads should be of well-insulated high-voltage cable. All connections must be securely fastened. Use heavy-gauge cable for all inter-connecting leads.